STOWARZYSZENIE EKONOMISTÓW ROLNICTWA I AGROBIZNESU
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ANALYSIS OF SELECTED ENVIRONMENTAL, ECONOMIC AND ENERGY EFFICIENCY INDICATORS OF OECD COUNTRIES BASED ON THE ENVIRONMENTAL KUZNETS CURVES THEORY

ANALIZA WYBRANYCH WSKAŹNIKÓW ŚRODOWISKOWYCH, EKONOMICZNYCH I EFEKTYWNOŚCI ENERGETYCZNEJ W KRAJACH OECD Z ZASTOSOWANIEM TEORII KRZYWYCH ŚRODOWISKOWYCH KUZNETSA

Key words: energy use – efficiency, GDP-level, greenhouse gas emission, environmental conditions of 27 OECD member countries, environmental Kuznets-curves

Słowa kluczowe: zużycie energii – efektywność, PKB, emisja gazów cieplarnianych, warunki środowiskowe w 27 krajach członkowskich OECD, środowiskowe krzywe Kuznetsa

Abstract. The nations need more and more energy to achieve their main objectives, launching the economic growth, or at least maintaining it. There is a relationship characterized by an inverted U-shaped curve between the emissions of pollutants (some local contaminants, such as nitrogen oxides, sulfur dioxide, heavy metals) per capita and GDP per capita distribution. We selected nine observation variables and twenty-seven observation units. Each observation units are OECD member states. It is expected to be confirmed that between the values of the energy consumption and greenhouse gas emissions and gross domestic product growth there is a statistically significant relationship. The so called developed countries need more and more energy to produce their GDP (for example agricultural production) and because of this their CO_2 emission increased in the observed period of time. The strongest relationship of the whole analysis is between the observation units, energy consumption and CO_2 emission. Unfortunately we can state that if a country wants to raise its GDP-level this country will use more energy to achieve this goal. The source of the large part of extra energy will be fossil fuels because they are still the cheapest energy sources.

Introduction

The main objectives of most of the states in the world are launching the economic growth, or at least maintaining it. To achieve these goals the nations need more and more energy, besides "there is no more fashionable answer to the woes of the global recession than green jobs" [Foroohar 2010]. There is a relationship characterized by an inverted U-shaped curve (Fig. 1) between the emissions of pollutants (some local contaminants, such as nitrogen oxides, sulfur dioxide, heavy metals) per capita and GDP per capita distribution [the Stern review 2006]. The above mentioned relationship does not exist between carbon dioxide emission and the level of GDP. In most of the states it is a fairly high income level where researchers can find a significant drop in CO_2 emissions. The researches indicate the emission will increase until 2050, although this depends on the further application of energy efficiency, green energy measures, and developing new technologies. In this paper we present a statistical analysis which is a part of a large-scale research in connection with climate awareness and energy management of rural communities.

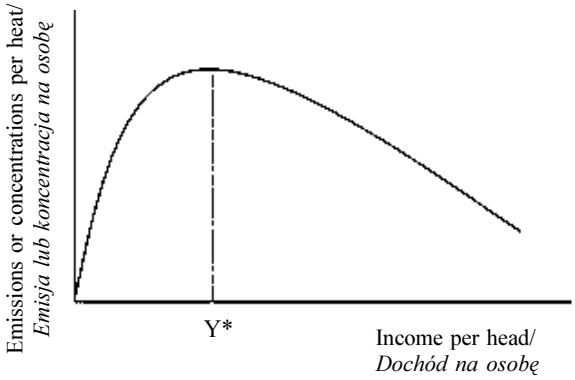

Figure 1. A hypothetical environmental Kuznets curve
Rysunek 1. Krzywa Kuznetsa
Source/*Źródło:* The Stern Review 2006

Material and methods

We selected nine observation variables (Tab. 1) and twenty-seven observation units [OECD 2008]. Each observation units are Organization for Economic Co-operation and Development (OECD) member states.

Table 1. An overview of the nine observation variables
Tabela 1. Zmienne przyjęte do analizy

GDPpercvar	**GDP, 2005 (billion US dollar in 2000 year's prices, purchasing power parity) % change (1990-2005)/** ***PKB, 2005 (mld USD w cenach z 2000 r., parytet siły nabywczej) zmiana [%] (1990-2005)***
Indprodpercvar	Industrial production: % change (1990-2005). Includes mining, quarrying, manufacturing, gas, electricity and water supply, and construction; production: construction is not included/ *Produkcja przemysłowa: zmiana % (1990-2005). Zawiera: górnictwo, kopalnictwo, gazownictwo, energetykę, dostarczanie wody, budownictwo, produkcję: budownictwo nie jest włączone*
Agrprodpercvar	Agricultural production: % change (1990-2005). Agriculture, forestry, hunting, fishing/ *Produkcja rolna: zmiana % (1990-2005). Rolnictwo, leśnictwo, łowiectwo, rybactwo*
Ncarspercvar	Road-vehicle stock change in % (1990-2005). Data from the four or more wheeled motor vehicles, except Italy where data include three wheeled freight vehicles/ *Zmiana liczby pojazdów drogowych w % (1990-2005). Dane uwzględniają czterokołowe pojazdy silnikowe, za wyjątkiem Włoch, gdzie uwzględniono pojazdy trzykołowe.*
Enusepercvar	Total energy consumption change in % (1990-2005). The allocation does not include the electricity trade/ *Ogólne spożycie energii w % (1990-2005). Nie uwzględniono handlu elektrycznością*
Enintpercvar	Energy intensity change in % (1990-2005)/*Zmiana intensywności zużycia energii w % (1990-2005)*
SO_xempercvar	Emissions of sulfur oxides change in % (1990-2005) not greenhouse gases/ *Zmiana emisji tlenków siarki w % (1990-2005), nie gazy cieplarniane*
$N_xO_y$empercvar	Emissions of nitrogen oxides change in % (1990-2005)/*Zmiana emisji tlenków azotu w % (1990-2005)*
CO_2empercvar	Carbon dioxide emissions change in % (1990-2005). CO_2 from energy use only; sectoral approach, not including international shipping and aviation fuel storage facilities/ *Zmiana emisji dwutlenku węgla w % (1990-2005), CO_2 tylko z użycia energii, podejście sektorowe, nie uwzględniono powierzchni magazynowych paliwa na potrzeby połowów międzynarodowych i lotnictwa*

Source/*Źródło*: OECD 2008

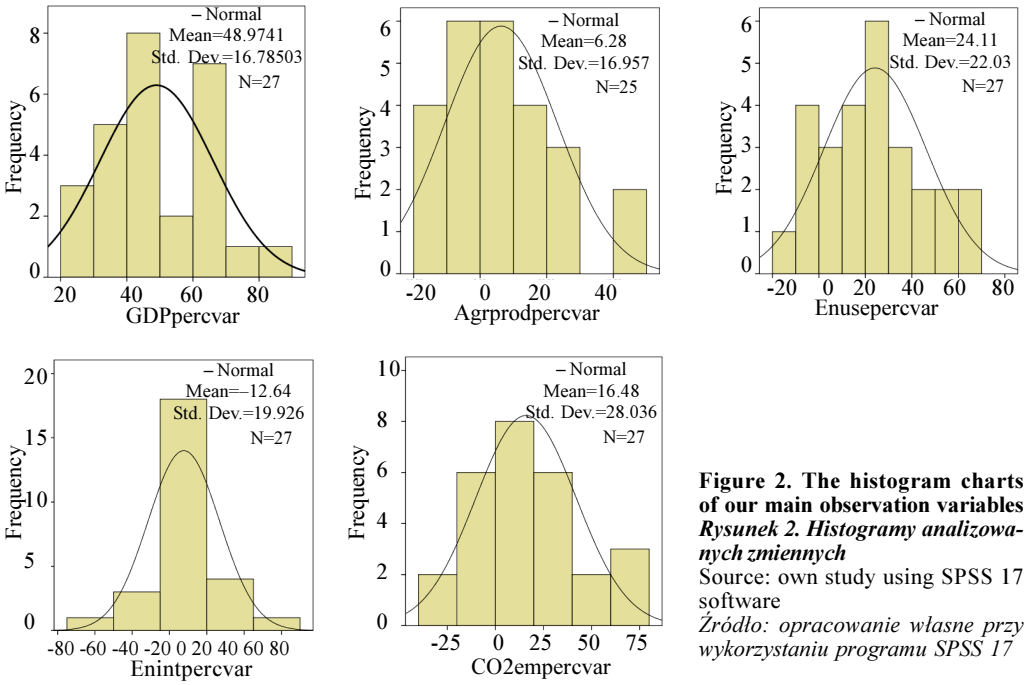

Figure 2. The histogram charts of our main observation variables
Rysunek 2. Histogramy analizowanych zmiennych
Source: own study using SPSS 17 software
Źródło: opracowanie własne przy wykorzystaniu programu SPSS 17

Using percentage values we can avoid difficulties because of different measurement units. It is expected to be confirmed that between the values of the energy consumption and greenhouse gas emissions and gross domestic product growth there is a statistically significant relationship although the energy intensity has decreased considerably in many countries. The emissions of sulfur oxides and nitrogen oxides have decreased substantially in most Western countries while the emission of carbon dioxide has increased over the past twenty years. For further examination of the basic data we used descriptive statistics (Tab. 2), bivariate correlation, and linear regression methods.

The key observation variables of our analysis will be the following ones: GDPpercvar, Agrprodpercvar, Enusepercvar, Enintpercvar, CO_2 empercvar. In order to present these observation variables we prepared histogram charts (Fig. 2).

The extreme values and the standard deviation have high values for the following indicators Ncarspercvar, Enintpercvar, SOxempercvar, NxOyempercvar, CO2empercvar. The modes of the variables SOxempercvar, NxOyempercvar have negative value while the mode of the variable CO2empercvar has positive value. The developed countries have reduced their nitrogen oxide and sulfur oxide emission but in many countries the emission of CO_2 is increasing unfortunately.

Table 2. The descriptive statistics matrix
Tabela 2. Macierz statystyki opisowej

Specification/ ***Wyszczególnienie***	**GDPper-cvar**	**Indprod-percvar**	**Agrprod-percvar**	**Ncarsp-ercvar**	**Enusep-ercvar**	**Enintp-ercvar**	**Soxemp-ercvar**	**NxOyem-percvar**	**CO2emp-ercvar**
N Valid/*Ważność*	27	26	25	27	27	27	27	27	27
Missing/*Braki*	0	1	2	0	0	0	0	0	0
Mean/*Średnia*	48.9741	38.1500	6.2840	68.0815	24.1111	-12.6444	-43.1111	-14.6667	16.4815
Std. Error of mean/ *Błąd standardowy*	3.23028	5.54918	3.39139	12.82073	4.23973	3.83469	8.40962	6.50816	5.39557
Median/*Mediana*	46.5000	28.5500	1.1000	37.9000	21.4000	-13.8000	-60.0000	-26.0000	15.0000
Mode/*Tryb*	22.20[a]	19.50	-15.80[a]	13.80[a]	-11.70[a]	-8.20	-88.00	-26.00	9.00[a]
Std. Deviation/ *Odch. standardowe*	16.78503	28.29536	16.95695	66.61846	22.03028	19.92564	43.69768	33.81738	28.03620
Variance/*Wariancja*	281.737	800.627	287.538	4438.019	485.333	397.031	1909.487	1143.615	786.028
Skewness/*Skośność*	0.288	1.102	0.937	2.047	0.259	-0.228	1.067	0.759	0.307
Std. Error of Skewness/ *Bl. stand. skośności*	0.448	0.456	0.464	0.448	0.448	0.448	0.448	0.448	0.448
Kurtosis/*Kurtoza*	-0.430	0.585	0.307	3.756	-0.715	4.899	0.182	0.018	-0.604
Std. Error of Kurtosis/ *Bl. stand. kurtozy*	0.872	0.887	0.902	0.872	0.872	0.872	0.872	0.872	0.872
Range/*Ranga*	64.10	109.80	63.70	251.20	78.60	119.80	148.00	129.00	103.00
Minimum/*Minimum*	22.20	3.20	-15.80	13.80	-11.70	-75.00	-90.00	-63.00	-33.00
Maximum/*Maksimum*	86.30	113.00	47.90	265.00	66.90	44.80	58.00	66.00	70.00
Sum/*Suma*	1322.30	991.90	157.10	1838.20	651.00	-341.40	-1164.00	-396.00	445.00
Percentiles 25	37.6000	17.8750	-8.6000	29.5000	9.6000	-22.9000	-77.0000	-43.0000	-5.0000
50	46.5000	28.5500	1.1000	37.9000	21.4000	-13.8000	-60.0000	-26.0000	15.0000
75	62.4000	55.4500	15.6000	74.2000	39.7000	-1.2000	-24.0000	7.0000	34.0000

[a] – Multiple modes exist. The smallest value is shown/*Istnieje wielokrotność trybu. Najmniejsza wartość jest pokazana.*
Source: own study using SPSS 17. software
Źródło: opracowanie własne przy wykorzystaniu program SPSS 17

Results

In order to confirm (or reject) our above mentioned preconception we performed a correlation analysis and we received the following matrix as a result (Tab. 3).

Table 3. The correlation matrix
Table 3. Macierz korelacji

		GDPper-cvar	Indprod-percva	Agrprod-percvar	Ncarsp-ercvar	Enusep-ercvar	Enintp-ercvar	Soxem-percvar	NxOyem-percvar	CO2em-percvar
GDPpercvar	Pearson Correlation	1	0.497**	0.363	0.415*	0.480*	0.120	0.609**	0.593**	0.473*
	Sig. (2-tailed)		0.0100	0.075	0.031	0.011	0.551	0.001	0.001	0.013
	N	27	26	25	27	27	27	27	27	27
Indprodpercva	Pearson Correlation	0.497**	1	-0.044	0.428*	-0.037	0.189	0.013	0.140	-0.036
	Sig. (2-tailed)	0.01		0.839	0.029	0.856	0.356	0.951	0.496	0.861
	N	26	26	24	26	26	26	26	26	26
Agrprodpercvar	Pearson Correlation	0.363	-0.044	1	0.057	0.378	-0.463	0.668**	0.642**	0.606**
	Sig. (2-tailed)	0.075	0.839		0.788	0.063	0.020	0.000	0.001	0.001
	N	25	24	25	25	25	25	25	25	25
Ncarspercvar	Pearson Correlation	0.415*	0.428*	0.057	1	0.309	0.097	0.247	0.311	0.295
	Sig. (2-tailed)	0.031	0.029	0.788		0.117	0.631	0.214	0.115	0.136
	N	27	26	25	27	27	27	27	27	27
Enusepercvar	Pearson Correlation	0.480*	-0.037	0.378	0.309	1	0.151	0.631**	0.740**	0.843**
	Sig. (2-tailed)	0.011	0.856	0.063	0.117		0.453	0.000	0.000	0.000
	N	27	26	25	27	27	27	27	27	27
Enintpercvar	Pearson Correlation	0.12	0.189	-0.463	0.097	0.151	1	-0.014	-0.030	0.119
	Sig. (2-tailed)	0.551	0.356	0.020	0.631	0.453		0.944	0.88	0.554
	N	27	26	25	27	27	27	27	27	27
Soxempercvar	Pearson Correlation	0.609**	0.013	0.668**	0.247	0.631**	-0.014	1	0.848**	0.749**
	Sig. (2-tailed)	0.001	0.951	0.000	0.214	0.000	0.944		0.000	0.000
	N	27	26	25	27	27	27	27	27	27
NxOyempercvar	Pearson Correlation	0.593**	0.140	0.642**	0.311	0.740**	-0.03	0.848**	1	0.881**
	Sig. (2-tailed)	0.001	0.496	0.001	0.115	0.000	0.88	0.000		0.000
	N	27	26	25	27	27	27	27	27	27
CO2empercvar	Pearson Correlation	0.473*	-0.036	0.606**	0.295	0.843**	0.119	0.749**	0.881**	1
	Sig. (2-tailed)	0.013	0.861	0.001	0.136	0.000	0.554	0.000	0.000	
	N	27	26	25	27	27	27	27	27	27

Explanations: *correlation is significant at the 0.05 level (2-tailed), **correlation is significant at the 0.01 level (2-tailed)/
*Objaśnienia: * korelacja jest istotna na poziomie 0,05, ** korelacja jest istotna na poziomie 0,01*
Source: see tab. 2
Źródło: jak w tab. 2

Table 4. The linear regression coefficients
Table 4. Współczynniki regresji liniowej

Model/*Model*	Coefficients*/*Współczynnik*						
	unstandardized/ *niestandaryzowany*		standardized/ *standaryzowany*	t	significant/ *istotność*	95.0% confidence interval for B/ *95% przedział ufności dla B*	
	B	std. error/ *bł. standard.*	Beta			lower bound/ *górny poziom*	upper bound/ *dolny poziom*
(Constant)	-1.766	9.572		-0.184	0.856	-21.733	18.202
GDPpercvar	-0.022	0.191	-0.014	-0.115	0.910	-0.421	0.377
Agrprodpercvar	0.704	0.215	0.461	3.279	0.004	0.256	1.152
Enusepercvar	0.791	0.158	0.628	5.018	0.000	0.462	1.120
Enintpercvar	0.244	0.165	0.188	1.481	0.154	-0.100	0.587

*dependent variable: CO2empercvar/*zmienna zależna: CO2empercvar*
Source: see fig. 1
Źródło: jak na rys. 1

Table 5. The matrix of Analysis of Variance (ANOVA)
Tabela 5. Macierz analizy wariancji ANOVA

Model/ *Model*	ANOVA[b]				
	sum of squares/ *suma kwadratów*	df	mean square/ *średnia kwadratów*	F	sig./ istotność
Regression/ *Regresja*	12 518.405	4	3129.601	17.413	0.000[a]
Residual/ *Rezydualna*	3 594..55	20	179.728		
Total/*Ogółem*	16 112.960	24			

Explanation: [a] – Predictors: (Constant), Enintpercvar, Enusepercvar, GDPpercvar, Agrprodpercvar,
[b] – Dependent variable: CO2empercvar
Oznaczenia: [a] Zmienne niezależne (stałe) Enintpercvar, Enusepercvar, GDPpercvar, Agrprodpercvar,
[b] Zmianna zależna: CO2empercvar
Source: see fig. 1
Źródło: jak na rys. 1

Table 6. The model summary matrix
Tabela 6. Macierz modelu

Model/ *Model*	Model Summary[b]/*Podsumowanie modelu*			
	R	R square/ *R kwadrat*	adjusted R square/ *dopasowany R kwadrat*	std. error of the estimate/ *standardowy błąd estymacji*
1	0.881[a]	0.777	0.732	13.40626

Explanations: see tab. 5/*Objaśnienia: jak w tab. 5*
Source: see fig. 1
Źródło: jak na rys. 1

The matrix above shows that there is a statistically significant relationship between the following variables: Agrprodpercvar and CO2empercvar and NxOyempercvar, Enusepercvar and CO2empercvar and NxOyempercvar, GDPpercvar and Enusepercvar, GDPpercvar and CO2empercvar, GDPpercvar and NxOyempercvar. To interpret correctly what has been said previously look the histogram of variable Enintpercvar in Figure 2. We can see that in most of the OECD member countries the possible to put the dot plot of the observation variables Agrprodpercvar – NxOyempercvar to here but it can be stated that the relationship is a bit stronger in this case as in the above mentioned case was. The strongest relationship of the whole analysis is between the observation units Enusepercvar – CO2empercvar see Figure 4. It is more than interesting. Our observation units are economically developed countries which use more and more green energy and the energy intensity values are decreasing but the above mentioned facts are not enough to unseal the relationship between Enusepercvar and CO2empercvar.

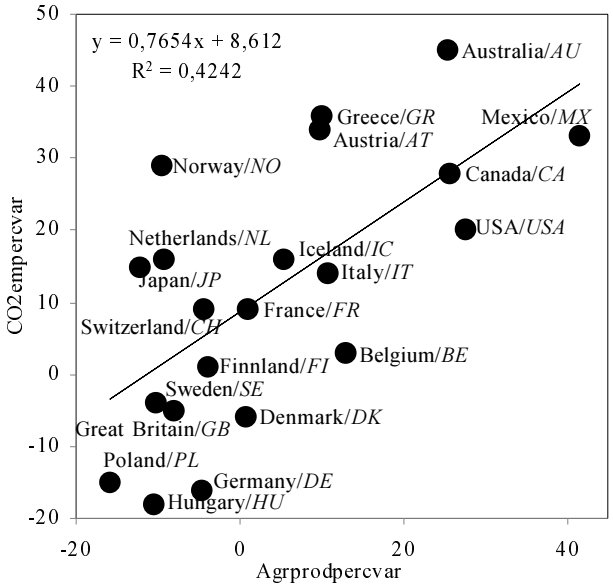

Figure 3. Dot plot of two observation variables (Agrprodpercvar – CO2empercvar)
Rysunek 3. Zależność między dwoma zmiennymi (produkcja rolna – emisja CO_2)
Source: see fig. 1
Źródło: jak na rys. 1

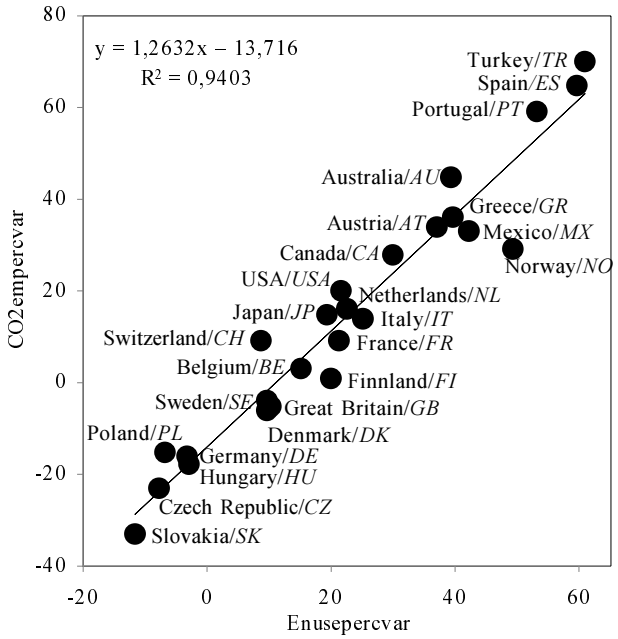

Figure 4. Dot plot of two observation variables (Enusepercvar – CO2empercvar)
Rysunek 4. Zależnośc między dwoma zmiennymi (zużycie energii – emisja CO_2)
Source: see fig. 1
Źródło: jak na rys. 1

Conclusion

Unfortunately we can state that if a country wants to raise its GDP-level this country will use more energy to achieve this goal. The source of the large part of extra energy will be fossil fuels because they are still the cheapest energy sources.

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Streszczenie

Kraje na świecie potrzebują coraz więcej energii, aby zwiększać wzrost gospodarczy lub przynajmniej utrzymać go na obecnym poziomie. W artykule dokonano analizy wybranych wskaźników środowiskowych, ekonomicznych i efektywności ekonomicznej z zastosowaniem teorii krzywych środowiskowych Kuznetsa. Do analizy wybrano dziewięć zmiennych i dwadzieścia siedem jednostek obserwacji, którymi były kraje członkowskie OECD. Postawiono hipotezę, że między wartościami zużycia energii i emisji gazów cieplarnianych oraz wzrostu produktu krajowego brutto jest istotny statystycznie związek. W wyniku analiz stwierdzono, iż kraje rozwinięte muszą zużywać coraz więcej energii do produkcji PKB i dlatego w obserwowanym okresie wzrosła emisja CO_2. Najsilniejszy związek zaobserwowano między jednostkami obserwacji, zużyciem energii i emisji CO_2. Można stwierdzić, że państwo chce zwiększyć PKB musi zużywać więcej energii, aby osiągnąć ten cel. Znaczna części dodatkowej energii będzie pochodziła nadal z paliw kopalnych, ponieważ są najtańszym źródłem energii.

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